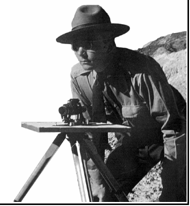
Soil and Sediment Erosion



BRIEF DESCRIPTION: Erosion, the detachment of particles of soil and surficial sediments and rocks, occurs by hydrological (fluvial) processes of sheet erosion, rilling and gully erosion, and through mass wasting and the action of wind [see sediment geochemistry and stratigraphy; stream sediment storage and load; wind erosion]. Erosion, both fluvial and eolian (wind) is generally greatest in arid and semi-arid regions, where soil is poorly developed and vegetation provides relatively little protection. Where land use causes soil disturbance, erosion may increase greatly above natural rates. In uplands, the rate of soil and sediment erosion approaches that of denudation (the lowering of the Earth's surface by erosional processes). In many areas, however, the storage of eroded sediment on hillslopes of lower inclination, in bottomlands, and in lakes and reservoirs, leads to rates of stream sediment transport much lower than the rate of denudation.
When runoff occurs, less water enters the ground, thus reducing crop productivity. Soil erosion also reduces the levels of the basic plant nutrients needed for crops, trees and other plants, and decreases the diversity and abundance of soil organisms. Stream sediment degrades water supplies for municipal and industrial use, and provides an important transporting medium for a wide range of chemical pollutants that are readily sorbed on sediment surfaces. Increased turbidity of coastal waters due to sediment load may adversely affect organisms such as benthic algae, corals and fish.

Significance: Soil erosion is an important social and economic problem and an essential factor in assessing ecosystem health and function. Estimates of erosion are essential to issues of land and water management, including sediment transport and storage in lowlands, reservoirs, estuaries, and irrigation and hydropower systems. In the USA, soil has recently been eroded at about 17 times the rate at which it forms: about 90% of US cropland is currently losing soil above the sustainable rate. Soil erosion rates in Asia, Africa and South America are estimated to be about twice as high as in the USA. FAO estimates that 140 million ha of high quality soil, mostly in Africa and Asia, will be degraded by 2010, unless better methods of land management are adopted.

Environment where Applicable: Potentially any land surface, but especially where disturbed for any reason, and sloping areas mantled with soil or loose sediment.

Types of Monitoring Sites: Representative sites in uplands and bottomlands.

Method of Measurement: Standard techniques, using erosion pins to detect soil creep or sheet and rill erosion, painted-rock lines and other sediment tracers to determine soil movement, cliff-recession and headcut markers, Young pits, repeated profile and slope measurements, and repeat photography using reference points. Repeat measurements of water and sediment collected in permanently installed hillslope troughs provide seasonal, annual and longer-term estimates of erosion and storage along hillslope profiles. Rates of soil erosion can be estimated using erosion-prediction equations developed during the last four decades. Among these algorithms are the Universal Soil Loss Equation (and its recent update the Revised Universal Soil Loss Equation), the Water Erosion Prediction Project model, and the European Soil Erosion Model.

Frequency of Measurement: Seasonally, annually to once per decade, depending on local conditions and parameter measured.

Limitations of Data and Monitoring: Erosion is very irregularly distributed in time and space, and it is difficult to determine how representative a particular site is.

Possible Thresholds: Gully erosion may become pronounced following cyclic periods of local to regional deposition, during which a critical threshold slope for drainageways is developed. When these threshold slopes are exceeded, the bottomlands adjacent to channels or drainageways may become unstable and subject to erosion. The slope angle above which instability occurs depends on local conditions of water and sediment distribution and on particle sizes of the sediment subject to transport. One result is a natural alternation of gully filling and evacuation of sediment, especially in arid areas over decadal periods. Another result may be intense rill and gully erosion where land use has reduced or destroyed soil cover (vegetation, litter, rock fragments) or has increased runoff and its erosive effects.

Key References:

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Wolman, W.G. & H.C.Riggs 1990. Surface water hydrology. The Geology of North America vol. 0-1, Boulder, Colorado: Geological Society of America. (especially paper by Meade, R.H., T.R.Yuzyk & T.J.Day, Movement and storage of sediment in rivers of the United States and Canada, p255-280).

Related Environmental and Geological Issues: Land degradation. Deposition of eroded soil particles with sorbed contaminants can endanger entire ecosystems along continental margins, in estuaries, wetlands and bottomlands, and on other areas of low slope angle. Soil erosion both affects and is affected by vegetation and crop cover.

Overall Assessment: Monitoring soil and sediment erosion is of the greatest importance in determining rates of land degradation.

Source: This summary of monitoring parameters has been adapted from the Geoindicator Checklist developed by the International Union of Geological Sciences through its Commission on Geological Sciences for Environmental Planning. Geoindicators include 27 earth system processes and phenomena that are liable to change in less than a century in magnitude, direction, or rate to an extent that may be significant for environmental sustainability and ecological health. Geoindicators were developed as tools to assist in integrated assessments of natural environments and ecosystems, as well as for state-of-the-environment reporting. Some general references useful for many geoindicators are listed here:

Berger, A.R. & W.J.Iams (eds.) 1996. Geoindicators: assessing rapid environmental change in earth systems. Rotterdam: Balkema. The scientific and policy background to geoindicators, including the first formal publication of the geoindicator checklist.

Goudie, A. 1990. Geomorphological techniques. Second Edition. London: Allen & Unwin. A comprehensive review of techniques that have been employed in studies of drainage basins, rivers, hillslopes, glaciers and other landforms.

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